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QUENCH DETECTION ON SUPERCONDUCTING CAVITY BY SECOND SOUND*

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Abstract

High gradient is very important for superconducting cavity, however it may be limited by quench on the cavity high field region. Quench can be caused by various reasons. To locate the position is the key to reveal the mysteries of quench. OST sensor was widely used to locate the quench position. Now we are developing the quench position detection system by RTD sensors such as Cernox. In this paper, we will show the design of the second sound system and testing results on the QWR cavity.

INTRODUCTION

Second sound is an effective way to detect the quench position on superconducting cavity. It was first used to detect the quench position on the SC split-ring resonators at ANL by a germanium resistor sensor [1]. Oscillating Superleak Transducers (OST) were used to locate the quench site of the 1.3 GHz 9-cell cavity at Cornell University [2]. Later after that second sound quench site detection of SC cavity by OST was widely used on the world. Second sound detection was also used in standard dressed TESLA-Shape SRF cavity at DESY [3]. Other types of sensor were also developed to detect second sound. For example, transition edge sensors was used in second sound test [4, 5].

A second sound quench site detection system is in developing for the PAPS. We chose the highly sensitive thermometers such as germanium bare chip resistor or Cernox bare chip resistor as the second sound detection sensors. Tests with SC cavity and heater in liquid helium at 2K were taken.

A 166.7 MHz Quarter wave resonator (QWR) developed for the photon source was used for the quench site location. The detector was put close to the quench area with high magnetic field.

PRINCIPLE

The speed of second sound in He-II is proper to be used for position detection. It is about 17m/s at 2K.

The time duration (RF quench time and first second sound signal) times the speed of second sound is the distance between quench point and detector. The quench position can be calculated by three detectors with known positions. Figure 1 shows the second sound signal transporting from the quench point to the detectors. Figure 2 shows the speed of the second sound [6].

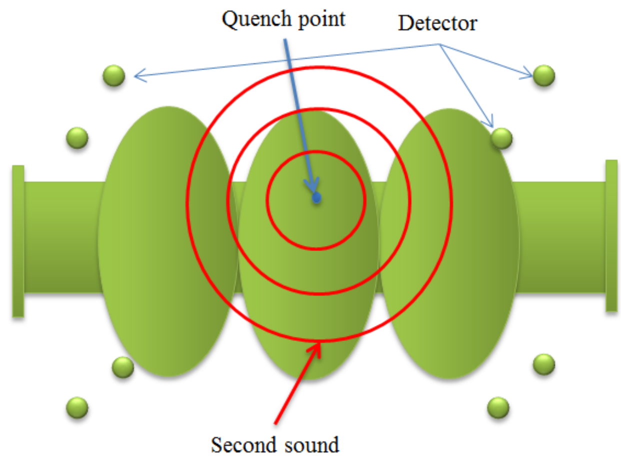

Figure 1: Principle of quench site detection by second sound.

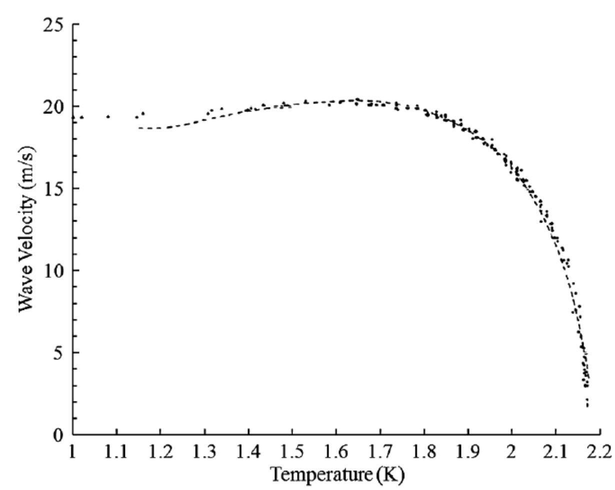

Figure 2: Velocity of second sound propagating in liquid helium.

EXPERIMENTS

There are several types of detectors can be used to detect the second sound signal. OST is a sensitive detector designed for second sound with a bias voltage. It was developed for detecting second sound only. Thermometer sensors can also be used to detect second sound signal such as Cernox bare chip sensors or germanium bare chip sensors. Transition edge sensors can also be used for such detections. Here we first tested the Cernox bare chip sensors and germanium bare chip sensors. We are also developing the OST sensor. It will be tested later and compared with the thermometry sensors.

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Figure 3 shows the circuits of the second sound detection by the RTD sensors such as Cernox and germanium resistors.

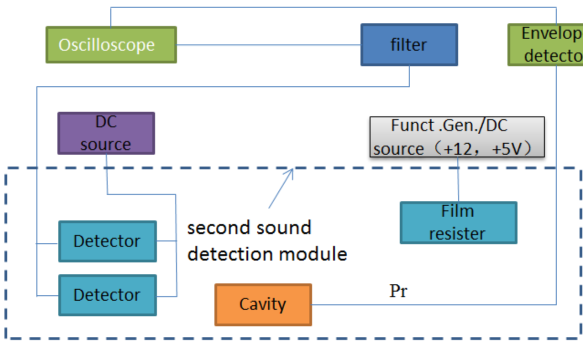

Figure 3: Circuits of second sound detection experiments in liquid helium.

To produce second sound signal without a superconducting (SC) cavity, a thin film heater was used as second sound source. A SC cavity was put in liquid helium dewar for quench site location. The detecting thermal resistors were connected with a current source and oscilloscope by four lead method. Signals from the resistor were displayed on the oscilloscope. There are noises from the coupler tuner motor and the RF source. Such signals are filtered by 2 KHz low pass filter and 50Hz notch filter.

Figure 4 shows the position of the second sound detector with the QWR cavity. The detector is a Cernox bare chip RTD (CX-1050-SD). It was placed close to the high magnetic field area of the QWR where quench may happen. A heating resistor was put close to the detector to produce second sound signal.

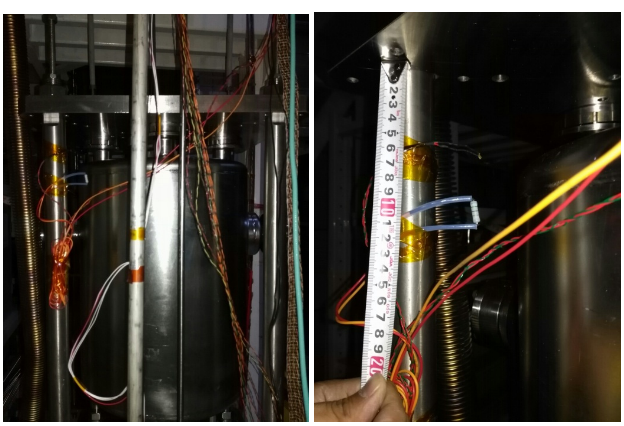
Figure 4: Position of second sound detector with QWR cavity.

In the vertical test of the QWR cavity, we investigated the second sound signal from the QWR cavity (see Fig. 5). However, there is 50Hz electric noise with the second sound signal. In later test, 50Hz notch filter is added and the noise is suppressed.

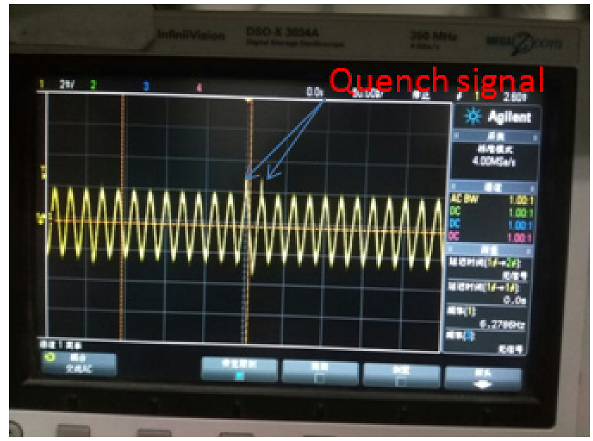

Figure 5: Second sound signal of QWR cavity.

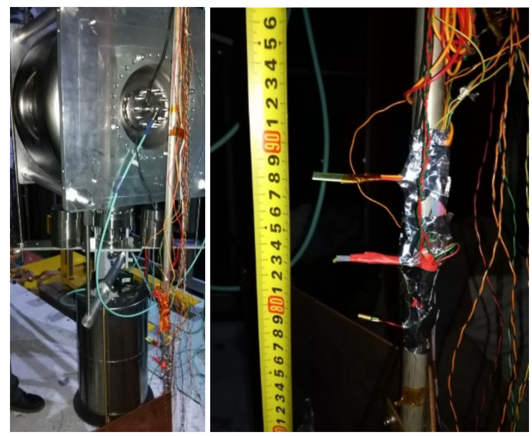
Figure 6: Position of second sound detector with spoke cavity.

In later test with a spoke cavity (Fig. 6), we have investigated the second sound signal with a film resistor (Fig. 7). Here we use a DC source for the film resistor to produce second sound signal. The DC source convert the 50Hz 220V electric to ±5V and ±12V DC source. Therefore the second sound signal has a frequency of 100Hz.

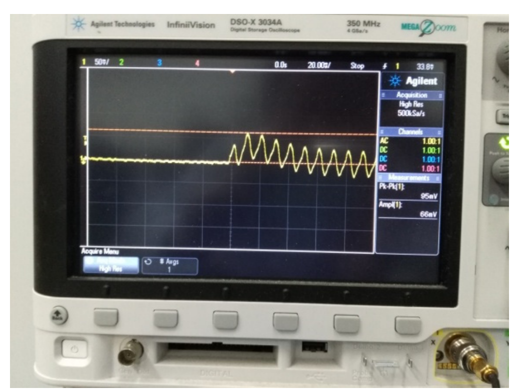
Figure 7: Second sound signal detected by germanium resistor from the film resistor.

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DETECTION SYSTEM

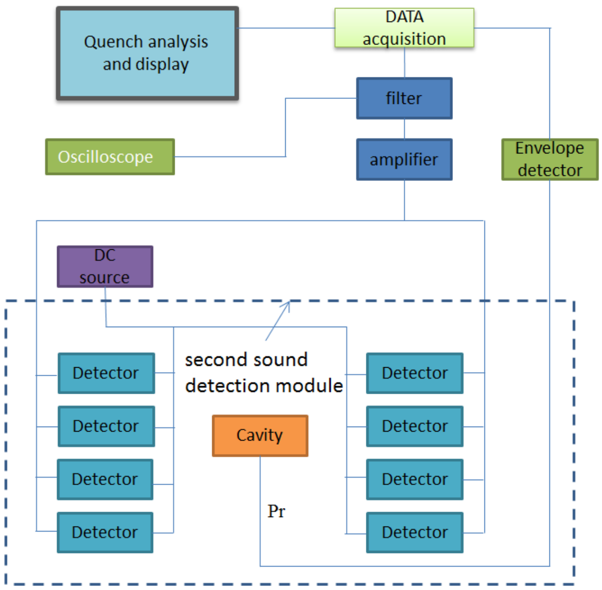

Figure 8: Circuits of second sound detection system of PAPS.

Figure 8 shows the circuits of the second sound detection system of PAPS. There are three testing dewars for cavity vertical test and each has a second sound detection module. Each module has eight sensors placed around the SC cavity. The second sound signals from each dewar are filtered and acquired by Labview with data acquisition card. The cavity quench signal (reflection signal of input power, Pr) is also stored in the Labview system and has synchronous time with the second sound signal from the detectors. There is one oscilloscope connected to the detector for display.

An analysis code will be created to calculate the quench site on the cavity. It will analysis the data saved by Labview system and give the 3D coordinate of the quench point on the SC cavity.

CONCLUSION

Second sound quench site location system is an economic high efficiency quench detection method for massive SC cavity inspection. We have tested two types of RTD sensors for the second sound detection. A second sound detection system and analysis code will be built for the PAPS. We are also developing the OST sensor for comparison.

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